MC0163

Department of Health and Social Security

Welsh Office

CI/SfB 1976
41 / (43) / Tu6 /

New edition 1977

HMSO 50p net

HEALTH TECHNICAL MEMORANDUM

ANTI-STATIC PRECAUTIONS: FLOORING IN ANAESTHETISING AREAS

2

Department of Health and Social Security: London

Welsh Office: Cardiff

Health Technical Memorandum Number 2

Anti-static Precautions: Flooring in Anaesthetising Areas

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I. Scope

1. This Memorandum gives guidance on anti-static floors in areas where general anaesthetics may be given and includes details of flooring which will meet hospital requirements satisfactorily in this respect and have satisfactory wearing properties. Electrical testing methods are described, and new recommendations are given on resistance limits. Other anti-static precautions, where general anaesthetics are given, are dealt with in Health Technical Memorandum No. 1.

II. Introduction

2. Electrostatic sparking constitutes an ignition hazard when flammable anaesthetics are administered by means of apparatus having a closed or partially closed breathing circuit. The explosion risk is considered to be negligible when flammable anaesthetics are administered by open techniques. The most effective means of eliminating the electrostatic ignition hazard is to exclude highly electrostatic materials and so provide an anti-static environment. This will necessitate the provision of flooring having suitable anti-static properties and ensuring that all persons and objects are in effective electrical contact with the floor by such means as anti-static footwear, trolley tyres etc. The electrical resistance of anti-static floors, however, should not be too low because it will then have the effect of increasing the electric shock hazard associated to equipment connected with mains electricity.

3. Formerly a minimum resistance to earth was specified; it was measured between an electrode making wet contact with the floor surface and earth and was therefore a means of assessing the electric shock risk to persons standing on the floor. Compliance with this test created difficulties with some new terrazzo floors because a long drying out period was necessary before the recommended test values could be obtained. Experience has shown that the electric shock risk due to low resistance floors is not serious, and no incidents directly attributable to low resistance floors have been reported. A significant mitigating factor is that anti-static footwear made to comply with the anti-static requirements of Health Technical Memorandum No. 1 will have sufficient inherent electrical resistance to safeguard against electric shock. Also it should be noted that mains operated electrical equipment is being increasingly used in operating departments, much of which has directly earthed exposed metal-work; under fault conditions the possibility of contact with earthed metal constitutes a much greater hazard than contact with earth via the flooring. It is for this reason that a high standard of electrical servicing is necessary in anaesthetising areas and this together with the correct choice of equipment must be regarded as the main safeguard against the risk of electric shock.

4. Although the wet electrode test to earth has been eliminated, a low resistance limit is now specified for dry electrode tests and this will provide an adequate safeguard against the possibility of floors being too electrically conducting.

III. Earthing

5. A direct earthing connection to anti-static floors has been found to be unnecessary. Floors having satisfactory anti-static properties are capable of safely equalising any electrostatic charges which are likely to develop on persons or objects which are in electrical contact with the floor under normal working conditions.

IV. Places where anti-static floors are required

6. Anti-static floors will be required only in rooms where flammable anaesthetics are likely to be administered by means of anaesthetic apparatus having a closed or partially closed breathing circuit. Normally this will be in operating theatres, anaesthetic rooms, rooms in each maternity unit for abnormal deliveries and treatment rooms in A & E departments.

7. In rooms where anti-static floors are necessary the floor should extend to the walls or to at least 2m. around any position where anaesthetic apparatus may be used.

V. Places where anti-static floors are not required

8. Anti-static floors normally will not be required in recovery rooms, intensive care rooms, plaster rooms, X-ray rooms and rooms used for normal deliveries. The reasons for this are indicated in the following paragraphs.

9. In the case of recovery and intensive care rooms full anti-static precautions would involve controlling the type of footwear, outer clothing, mattresses, bedding, the use of plastic materials and the interchange of moveable apparatus between the room and elsewhere.

When it is clinically desirable to administer a flammable anaesthetic via a conventional circuit in these areas, provided that the breathing circuit is constructed of anti-static rubber and the staff wear anti-static footwear, the potential risk of an explosion is considered to be of the order of one in a million. The safety margin can be increased by damping the area of the floor that is within touching distance of the breathing circuit.

10. In X-ray departments and radiotherapy treatment rooms it is impracticable to ensure that the X-ray table and associated apparatus is completely free from a sparking hazard. The extent of the additional risk due to electrostatic charges and the precautionary measures to be taken against this are as outlined above. A further factor is that the presence of high voltages makes a non-conductive floor an additional safeguard against electric shock hazards.

11. As the overall risk in areas where anaesthetics are not normally given is low it is difficult to justify the provision of anti-static floors for the occasional administration of anaesthetics few, if any, of which will involve a flammable agent. As indicated in the two previous paragraphs it is likely to be impossible to ensure that other associated anti-static precautions are adequately enforced. Thus plaster rooms and rooms for non-operative deliveries normally would not need anti-static floors.

12. In any areas where misunderstanding is possible an appropriate warning notice should be fixed at a suitable point. The following is suggested as a guide to wording.

"ANAESTHETIST

This room is not provided with an anti-static floor.

Please weigh the risks of using a flammable agent against the clinical advantages and take appropriate precautions.

These precautions should include:—

The use of a breathing circuit of anti-static rubber or an open method of administration.

The wearing of conductive footwear such as cotton overshoes.

The damping of the area of the floor that is within touching distance of the breathing circuit."

VI. Recommended limits of electrical resistance

New floors

13. When tested as desribed in Section VII, the recommended limits of electrical resistance are:

Upper limit: average value not exceeding 2 megohms between two separate electrodes spaced 600mm. apart, with no individual reading exceeding 5 megohms.

Lower limit: average value not less than 50,000 ohms measured between two separate electrodes spaced 600mm. apart with no individual reading less than 20,000 ohms.

14. All new anti-static floors should be constructed to comply with these limits. As is mentioned above, the resistivity of some terrazzo floors may be on the low side during the initial drying out period, but these should recover sufficiently to comply with the lower limit within six months of laying.

15. New terrazzo floors showing high resistance readings initially are unlikely to improve with time and must be regarded as unsatisfactory, either due to incorrect composition or faulty laying techniques.

Existing floors

16. For existing anti-static floors the recommended value of electrical resistance is: the average value not to exceed 20 megohms between two separate electrodes spaced 600mm. apart, with no individual test reading exceeding 50 megohms. Where the resistance of existing floors exceeds the recommended values it will be necessary to consider the local conditions in deciding the course of action.

17. The recommended limits of electrical resistance include a reasonable margin of safety against the possibility of some variation in the resistance occurring under service conditions and the main factors to be considered are the extent to which flammable anaesthetics are used and the conditions and suitability of the floor in other respects.

18. High resistance floors can be rendered temporarily anti-static by damping the surface; the use of a wetting agent such as a detergent will increase the duration and effectiveness of the treatment. A more effective result will be achieved with terrazzo floors by swabbing the floor with a weak solution of sodium chloride, e.g. isotonic saline.
However, this solution should be washed off, when it is no longer required that the floor be anti-static, as it may soak in and erode the cement of the terrazzo floors. These methods may be considered to be practicable where flammable anaesthetics are used only occasionally and the floors are otherwise in a satisfactory condition.

19. In rooms where flammable anaesthetics are regularly used, steps should be taken, as the opportunity and resources permit, to provide a new floor having satisfactory properties.

VII. Electrical tests

Recommended test instrument

20. The test instrument recommended is an insulation testing ohm-meter, having an approximate open circuit voltage of 500 volts D.C. and capable of measuring resistance values of between 10,000 ohms and 50 megohms.

Test electrodes (See Appendix also)

21. Each electrode should weigh about 1 kg. and have a flat dry contact area of approximately 2500 sq. mm. which should comprise a surface of tin or tin faced lead foil 0.012—0.025 mm. thick, backed by a layer of soft rubber 6 mm. thick and measuring not more than 50 International Rubber Hardness Degrees (IRHD). If tin foil is not available, aluminium foil about 0.025 mm. thick may be used. This will give higher resistance measurements than those obtained with pure tin foil, particularly above 10 megohms on terrazzo.

Method of test

22. The electrodes should be placed approximately 600mm. apart and the resistance measured between them.

Floor preparation

23. The floor surface shall be wiped clean with a dry cloth before electrodes are applied. Tests may not be reliable if made within two hours of the floor being wetted e.g. for cleaning. A newly laid terrazzo floor should be conditioned by regular washing daily for at least one week before measurements are taken. A newly laid PVC floor should be washed and allowed to dry before measurements are taken.

Results

24. Sufficient tests should be made for the results to be representative of the resistivity of the whole floor. As a general indication, one test should be made for each two square metres of a new floor, and not less than five locations for routine tests on floors in service.

25. The results of the tests should be averaged and the average value and individual test values should be within the limits of electrical resistance specified in Section VI.

VIII. Types of flooring

26. The sub-floor construction will influence the choice of floor finish. Where the sub-floor is suitable for a rigid type of finish, terrazzo flooring is usually preferred for operating theatres, anaesthetic rooms and delivery rooms. The electrical resistance of terrazzo floors is rather difficult to control, particularly with in-situ constructed floors, and wide variations can arise unless a satisfactory specification is used and rigidly adhered to. Good quality terrazzo has a hard impervious finish, which has fairly stable electrical properties, but porosity associated with inferior terrazzo can cause wide fluctuations in resistivity. Hydraulically pressed, precast terrazzo tiles are to be preferred because generally they have more stable electrical properties than in-situ terrazzo floors.

27. Where a resilient type of floor finish is required or where the depth available for the floor finish is restricted, anti-static vinyl type flooring is usually preferred. In the past anti-static rubber and linoleum floors were available, but vinyl has the advantage of greater resistance to staining fluids and solvents and the joints can be welded after laying. Carbon black has been largely used as the conducting medium and the electrical resistance of floors incorporating carbon black has been generally satisfactory. Earlier types of anti-static vinyl floors were black but the material is now available in other colours with black patterning. With this type of heterogenous material, no point on a non-conducting area should be more than 12mm. from a conducting surface.

28. Other conducting agents have also been used to impart anti-static properties to rubber and pvc types of flooring. These have been found to be less satisfactory than carbon black and the reliability of anti-static agents other than carbon black has yet to be proved. To encourage development there is no objection to new types of anti-static flooring being laid in small trial areas, but satisfactory assurances as to their lasting properties should be obtained before they are used for larger areas.

Anti-static floors with embedded heating systems

29. The resistivity of terrazzo may increase seriously where a heating system is incorporated in the sub-floor. Similar variations may also occur where an embedded heating system is incorporated in the ceiling directly beneath an anti-static floor unless adequate steps are taken to restrict the temperature rise of the floor. This arises from the fact that an increase in the operating temperature of the floor reduces the residual moisture content and thereby raises the resistivity. The fluctuations which can occur under these conditions will probably result in the electrical resistance of terrazzo type floors exceeding the limits recommended for anti-static purposes, and the use of terrazzo with embedded floor heating is not recommended in places where anti-static precautions are necessary.

30. The resistivity of anti-static vinyl and similar floor coverings which incorporate carbon black as the conducting agent may also be affected by heat, enough to cause the resistance of these types of flooring to fall outside the recommended limits. When ordering anti-static floor coverings for use with embedded heating systems it is advisable to state the maximum operating temperature of the floor.

IX. Recommended floors

A. Terrazzo precast tiles

31. Tiles should be manufactured to comply with B.S.4131. Floors should be laid in accordance with British Standard Code of Practice C.P.202 and with the following:

Size of tiles

The preferred size is 300mm. x 300mm. 30mm. nominal thickness.

Composition of tiles

The terrazzo facing of the tile should be not less than 6mm. and not more than 10mm. thick and should consist of properly graded marble aggregate as described for in-situ terrazzo to produce a mix not richer than 2 parts aggregate to 1 part cement by volume.
The tile backing should consist of 3 parts of suitable aggregate to 1 part cement. The amount of mixing water should be the least needed for proper workability. Manufacturing pressure on the tile should be at least 3.5MN/m².

Method of laying

The sub-floor or separation layer (where provided) should be prepared and covered with wire mesh as described for in-situ terrazzo. The bedding mortar should consist of cement and sharp washed sand not richer than 1 part cement, 3 parts sand and should be not less than 12mm. thick. It is unnecessary to incorporate carbon black in the bedding mortar where the floor will be maintained within normal temperature limits, i.e. where there is no buried heating. The joints should be pointed with mortar to match the tiles.

Finish

Where a smooth, lip-free surface is required the floor should be ground after a suitable curing period, using a fine abrasive, e.g. an 80 grit stone, as recommended for in-situ terrazzo.

Inspection

The work should be properly supervised during laying and thoroughly inspected after final polishing. The tiles should be tapped to ensure that they are properly bedded.

B. Terrazzo: in-situ

32. The materials used and the method of construction should be generally in accordance with the British Standard Code of Practice C.P.204. Attention is specially drawn to the clause dealing with the prevention of cracking.

Special materials required

Wire netting:

Heavily galvanised steel wire netting, not thinner than 0.71 mmU (22 s.w.g.) and mesh not exceeding 25mm. and should comply with B.S.1485.

Binding wire:

0.71mmU (22 s.w.g.) galvanised steel binding and jointing wire.

Carbon black:

Carbon black produced from the thermal decomposition of acetylene gas or other types of carbon black which will impart similar electrical conducting properties to the floor should be used. To obtain satisfactory diffusion throughout the mixture, the carbon black should be in powder form, dry and free from lumps.

Method of laying

(i) The sub-floor and separating layer (if any) should be prepared in the usual way and be free from dust or grease etc. The use of a separating layer is recommended where possible movement of the structure is to be expected or where precast slabs have been used, or an old slab is used. Where the sub-floor is formed of recently laid reinforced concrete, properly designed to limit movement and support the full load, it is recommended that the screed be bonded to the sub-floor.

(ii) The netting should be laid over the entire surface area prepared for the screed. There should be a slight overlap at the sides of the longitudinal runs and these should be bonded together at distances not exceeding 1m. with 0.71mmU (22 s.w.g.) galvanised binding wire.

NOTE: Bare copper binding wires should not be used because of the possibility of electrolytic action between copper and zinc galvanising.

Where the screed thickness is less than 40mm.* or where a separation layer is used it is recommended that the mesh is secured to the sub-floor at intervals of approximately 600mm. to reduce the possibility of the terrazzo rising away from the sub-floor. (Special nails can be bought for this purpose).

(iii) The screed between the terrazzo topping and the sub-floor should have a thickness of 40—65mm.* and should consist of 1 part cement 4 parts of aggregate, consisting of sharp washed sand and 6—9mm. shingle or crushed aggregate, properly graded according to thickness. The carbon black should be added to the cement in ratio 1 kg. of black to every 50 kg. of cement. The cement and black should be thoroughly mixed dry.

To obtain uniform electrical properties throughout the floor, special care must be given to this mixing and it is recommended that it is done in a mechanically driven mill or mixer. It is very important that the amount of mixing water should be the minimum consistent with proper workability. Where the screed is less than 40mm. thick special attention should be given to ensuring a good bond to the sub-floor and to securing the wire mesh as described above.

*Screeds having a minimum thickness of less than 40mm. are not recommended and should not be used with a separation layer between the screed and the sub-floor. Under no circumstances should the thickness be less than 30mm.

(iv) The terrazzo topping should be not less than 16mm. thick and should be laid whilst the screed is still plastic; if this is not possible a slurry of neat cement should be brushed on to the base before the terrazzo is laid. The terrazzo should be composed of 2 parts marble aggregate to 1 part cement. The marble aggregate should be composed of equal parts of size 3—5mm. marble and 5—7mm. marble, any disproportionality being in favour of the larger size. The 2/1 mixture should be laid as a matrix with size 7—10mm. or preferably 10—15mm. marble aggregate closely sprinkled on the surface and thoroughly tamped down into the matrix to provide a compact surface with the maximum amount of marble exposed. Aggregate smaller than 3mm. should not be used. The aggregate should be free from dust and impurities and it is important that the water to cement ratio is kept as low as is practicable to prevent excess shrinkage on drying, and to minimise the risk of cracking.

(v) Dividing strips should be plastic or ebonite and penetrate the full depth of the terrazzo and screed. They should be bedded into grooves provided in the screed using anti-static mortar similar to the screed.

(vi) Fine surface grinding treatment is necessary to obtain the required smooth imperforate finish as obtained for example with an 80 grit polishing stone. Grinding should be continued until the surface is satisfactory.

(vii) The floor should be kept in a damp condition for several days after laying, and subsequently should be covered as necessary to prevent a too rapid drying out, e.g. during the summer months or where the floor will be subjected to artificial heat.

Inspection

33. The work should be inspected during progress and after final polishing. Indications of poor quality terrazzo are:

(i) Hair cracks or crazing visible with the aid of a lens under a bright light or after removing surface water from the floor with a squeegee.

(ii) Shrinkage cracks visible at the dividing strips.

(iii) Corners of sections lifting and tapping hollow.

(iv) High moisture absorption due to excessive porosity.

(v) Surface powdering.

(vi) Pitting due to aggregate coming out of the surface.

C. Anti-static vinyl floors

34. This type of floor covering is usually supplied in widths of 900mm.—1800mm. or in tile form. There are obvious advantages in using the greater width to reduce the number of joints. The surface of the materials should preferably have uniform conductivity but where for purposes of embodying a pattern, small non-conducting areas are included, they should be arranged so that no point on a non-conducting area is more than 12mm. from a conducting surface. It is recommended that the flooring should have welded joints.

35. Laying should be in accordance with British Standard Code of Practice C.P.203 and with the following:

Preparation of sub-floor

The sub-floor should be even, clean and dry, and if in direct contact with the ground should incorporate an effective waterproof membrane. Uneven floors should be screeded to produce a flat, even surface to receive the floor covering. It is usually preferable for screeding to be carried out by the flooring contractor to ensure that the screed is compatible with the adhesive to be used to secure the floor covering.

Electrical bonding

Satisfactory uniform electrical conductivity throughout the floor is important and some form of electrical bonding may be necessary. The bonding and the type of adhesives used should be as recommended by the floor manufacturers for use with their particular product and have characteristics which will permit obtaining the required electrical resistance from the completed floor. Bonding strips when used should be copper or brass e.g. 12mm. wide 0.075—0.150 mm. thick. Bonding strips should be insulated from any earthed metalwork encountered.

Inspection

The work should be thoroughly inspected on completion. There should be no sign of the flooring material lifting and the welded joints should be intact, giving a completely watertight finish.

X. Marking of anti-static floors

36. It is frequently useful to know the history of anti-static floors and it is recommended that they are marked, e.g. with a brass plate inserted in a suitable position and inscribed with the following information:
ANTI-STATIC FLOOR LAID BY.....
(name of firm), date.....

XI. Maintenance

37. It is important that the maintenance of anti-static floors should not impair their anti-static properties. Wax and other polishes and seals which leave a film on the surface of the floor are liable to do this.

38. The manufacturers advice should be followed and it should be ascertained by electrical testing that the maintenance procedures are not affecting the anti-static properties of the floor.

Terrazzo floors

39. Under normal conditions these floors should be cleaned with water using a neutral detergent. In the case of terrazzo floors which may have been subjected to heavy staining a mild (neutral) cleansing powder can be used. All cleaning procedures should be followed by rinsing and drying preferably using a suction drier. Soap and soap powders must not be used; with their use a soap scum is inevitable and this reduces the anti-static properties of the floor.

40. The necessity and choice of disinfectant for use in operating theatres needs careful consideration. The Cross-Infection Committee of the hospital should be consulted as many disinfectants commonly used have severe disadvantages. The most efficient, i.e. clear soluble phenolics can cause staining of terrazzo (as can the black and white phenolics). They are also inactivated by certain types of plastic used for sponge mops.

Anti-static vinyl floors

41. Vinyl floors may be washed with the minimum amount of water and a liquid detergent when necessary.

Periodic testing

42. The electrical resistance of anti-static floors should be measured periodically (e.g. at half yearly intervals) using the test method described, the floors being divided into sections and the results entered in a log book so that a continuing history of the various sections is recorded. If successive readings show only slight change the testing interval may be extended to yearly.

References

BRITISH STANDARDS INSTITUTION

1 B.S.1485 Galvanised wire netting.
2 B.S.2050 Electrical resistance of conductive and anti-static products made from flexible polymeric material.
3 B.S.4131 Terrazzo tiles.

CODES OF PRACTICE

4 C.P.202 Tile flooring and slab flooring.
5 C.P.203 Sheet and similar flooring.
6 C.P.204 In-situ flooring.

Appendix—for information only

Proposed IEC Electrode and Resistance Limits

A1 The International Electrotechnical Commission (IEC) Technical Sub-committee 62A, Working Group 2 has proposed the adoption of a French floor testing electrode which is shown in Figures 1a and 1b. If adopted by the IEC the electrode will be expected to become the standard for use in the UK in place of the existing electrode (see para. 21 above). However this will not be possible before 1978.

A2 Details of the proposed IEC electrode, tests and resistance limits are given here for information. It should be noted that use of the proposed IEC electrode, with the upper limit specified, in place of the two electrode method currently in use in the UK, will permit the use of floors having a much higher electrical resistance.

A3 **Recommended Limits of Electrical Resistance**

Upper limit: average value not exceeding 100 megohms between electrode and earth with no individual value exceeding 100 megohms. Lower limit: average value not less than 50,000 ohms between electrode and earth with no individual value less than 20,000 ohms.

A4 **Electrical Tests**

Test Electrode. The electrode should be as specified in IEC TC62A WG2 Draft Recommendations for Measuring Anti-static Floors. Drawings of the proposed electrode and its associated rubber pads are shown in Figures 1a and 1b respectively.

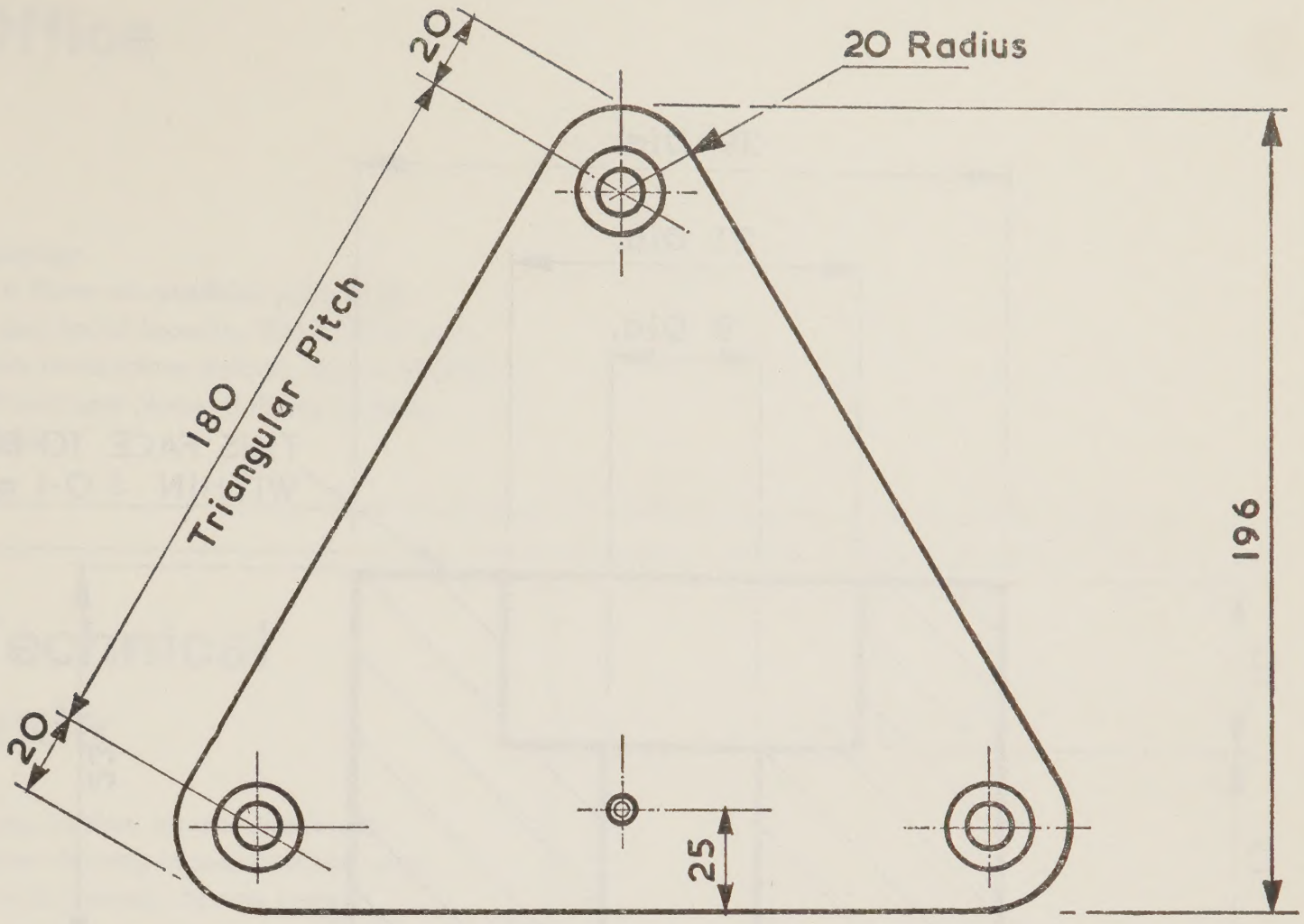
The pads should be in dry contact with the floor and a weight greater than 50 kilograms should be placed upon the upper surface of the electrode. This latter condition can usually be met by standing on the electrode which is designed with this in mind.

Method of Test. The electrode should be placed in the area to be measured and the resistance measured between electrode and earth. In the event that an extremely high value of resistance be measured it may be considered worthwhile to take the measurement between two electrodes of this type spaced at least 2m. apart. Half of the average value of resistance measured in this way should be taken as the correct average value for the purpose of comparison with the limit.

At least five measurements should be made around any operating table.

A5 **IEC Recommendations** (Reference Document)

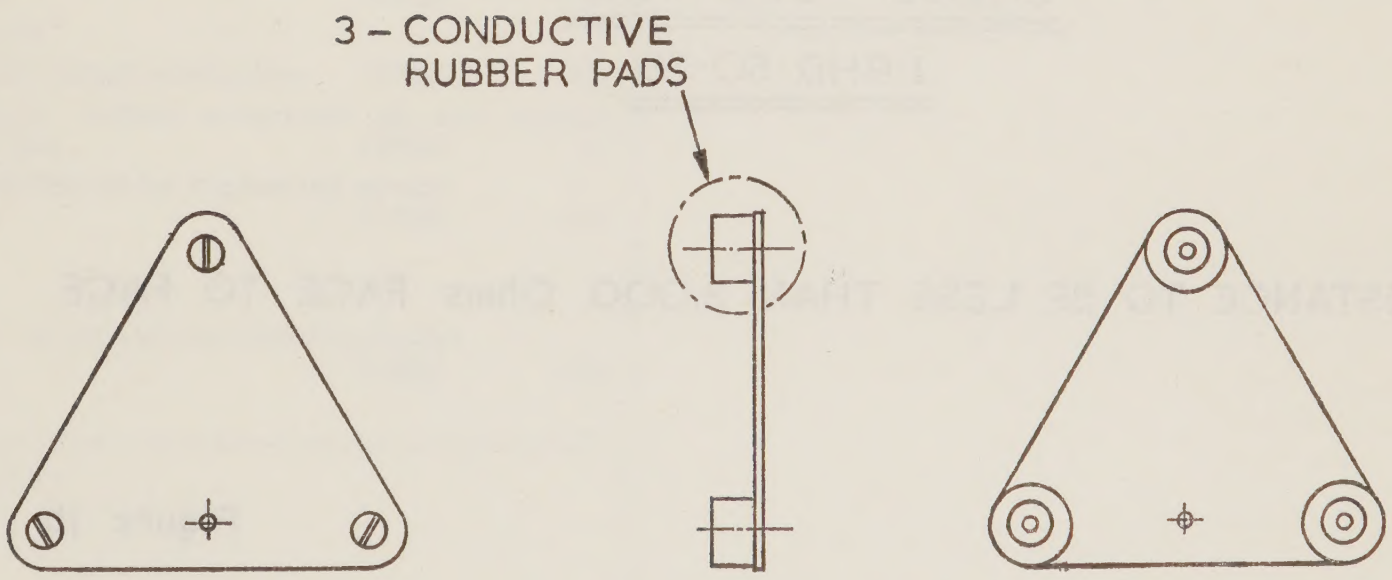
Draft Recommendations for Measuring Anti-static Floors (TC62A, WG2)



ALUMINIUM ALLOY SHEET 5mm THICK

3 - C S K. HOLES 8·5mm DIA.
3 - 8mm DIA. I.S.O. FINE SCREWS 25mm LONG FITTED WITH PLAIN WASHER & SELF LOCKING NUTS Eg. NYLOC.
1 - C S K. & TAPPED HOLE TO TAKE 4 mm DIA. I.S.O. COARSE SCREW 20mm LONG.

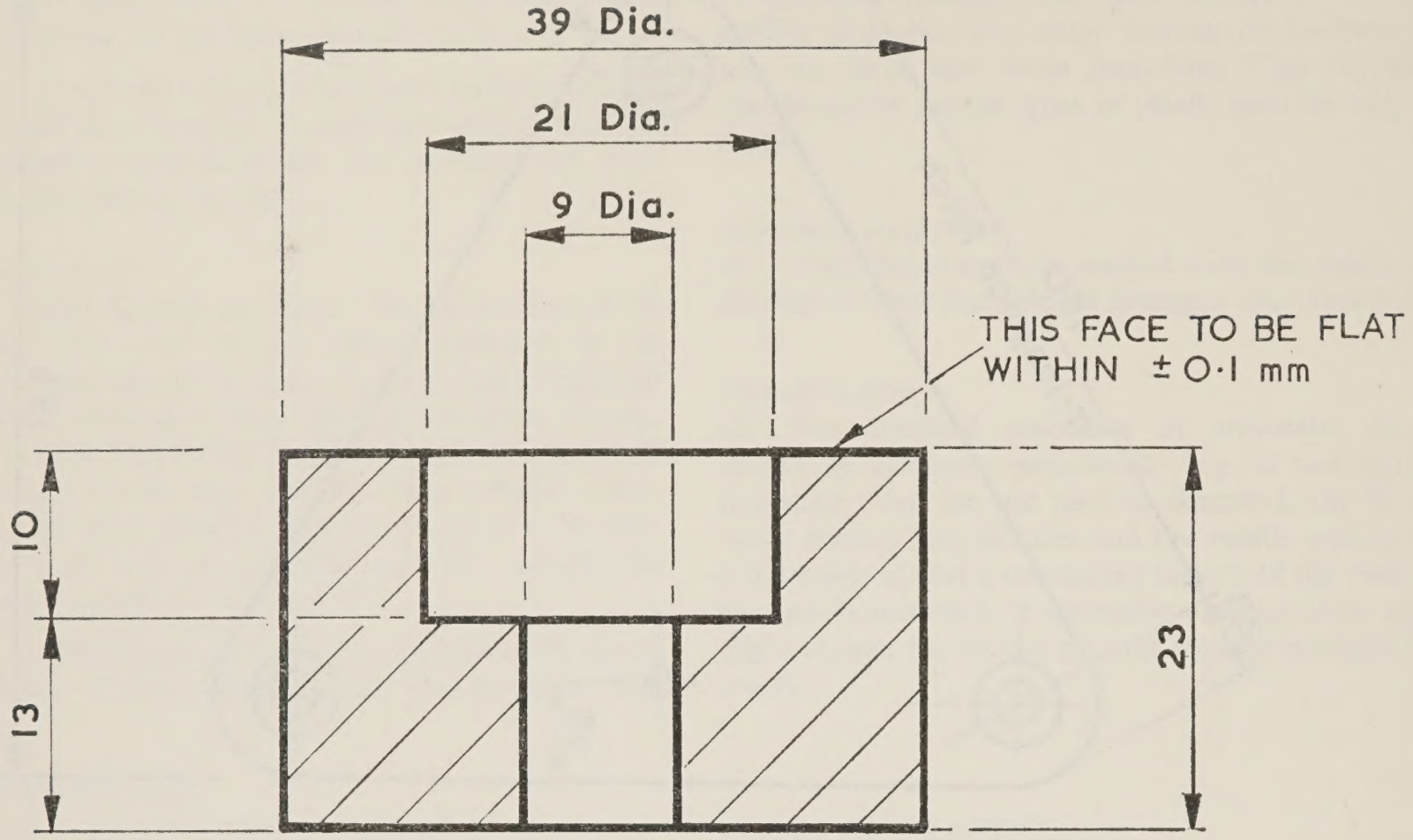
Scale 1:2



TEST ELECTRODE FOR ANTISTATIC FLOORS

Scale 1:5
All dimensions in mm

Figure 1 a



CONDUCTIVE RUBBER PAD

CROSS SECTION

I RHD 50-70

RESISTANCE TO BE LESS THAN 3,000 Ohms FACE TO FACE

Figure 1b

Scale 2:1
All Dimensions in mm.

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25	In preparation		
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Printed in Wales for Her Majesty's Stationery Office
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Dd. 585770 K40 6/77

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First published 1962
Fourth edition 1977

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ISBN 0 11 320680 1